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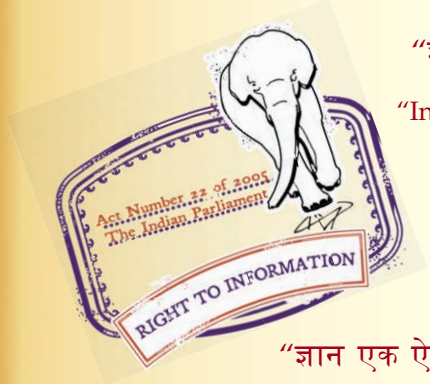
IS 11692 (1986): Method of tests for electro-slag remelting furnaces [ETD 17: Industrial Electroheating Equipment]



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(Reaffirmed 2003)

Indian Standard

METHODS OF TESTS FOR ELECTRO-SLAG REMELTING FURNACES

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NEW DELHI 110002

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Indian Standard

METHODS OF TESTS FOR ELECTRO-SLAG REMELTING FURNACES

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Indian Standard

METHODS OF TESTS FOR ELECTRO-SLAG REMELTING FURNACES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 26 June 1986, after the draft finalized by the Industrial Electroheating Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The objective of this standard is to specify the methods of tests for electro-slag remelting furnaces, to permit the determination of essential parameters and technical characteristics of electro-heating installations.

0.3 This specification does not contain a mandatory list of tests and is not restrictive. Tests may be selected from the proposed list of tests, as required, for the characterization and evaluation of a furnace. If necessary, additional tests may be carried out, in agreement between the manufacturer and the user.

0.4 In preparing this standard, considerable assistance has been derived from IEC Doc : 27 (Central Office) 60 'Test methods for electro slag remelting furnaces', issued by the International Electrotechnical Commission (IEC).

0.5 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard applies to electroheating installations for the remelting of metals through direct resistance heating of a conductive slag.

*Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions, in addition to those given in IS : 1885 (Part 51/Sec 1 and 2)-1979*, shall apply.

2.1 Electro-Slag Remelting Furnace — Melting furnace in which the charge, normally a consumable electrode, is melted by resistance heating of an electrically conductive molten slag. The slag is contained in a mould (crucible).

2.2 Electroheating Installation with Electro-Slag Remelting Furnace — Complete assembly of an electroheating device and the electrical and mechanical equipment necessary for operation and utilization of an electro-slag remelting furnace.

The electrical equipment comprises, in particular, the conductors and switchgear in the power, control, and regulating circuits, and the melting power supply(ies), when the device has its own melting power supply(ies).

2.3 Power of an Electroheating Installation (Apparent Power, S, in kVA or Active Power, P, in kW) — The electric power measured at the input of the supply line.

2.4 Power-Factor of an Electroheating Installation ($cos\ \theta$) — The ratio of the active power to the apparent power, measured at the input of the supply line.

2.5 Specific Energy Consumption e (kWh/kg) — Ratio of the total amount of electric energy (kWh) measured at the input of the supply line, which is consumed by an electroheating installation for melting the charge in normal operating conditions agreed upon between the manufacturer and the user, to the weight of the ingot manufactured (kg).

2.6 Mould (Crucible) of an Electro-Slag Remelting Furnace — Non-consumable container which shapes the ingot to be produced by the electro-slag refining process and which contains the molten slag.

2.7 Secondary Electrical Circuit of an Electro-Slag Remelting Furnace — Electrical circuit which is closed by the melting power supply and includes the following:

a) Output terminals of melting power supply;

b) High current feeder (busbars and/or cables);

c) Bus switches, if required;

*Electrotechnical vocabulary: Part 51 Industrial electroheating,
Section 1 General terms.
Section 2 Resistance heating.

d) Electrode clamping;
e) Electrode stub;
f) Consumable electrode;
g) Conductive molten slag (not included in the short circuit tests);
h) Remelted ingot; and
j) Base plate (depending on system connections).

2.8 Electro-Slag Furnace Electrode(s) (Consumable Electrode) — Solid part(s) in contact with the molten slag which carries the electrical current necessary for the melting operation and is constituted of the material necessary for the formation of the ingot.

2.9 On-load Voltage of an Electro-Slag Remelting Furnace — Voltage which can be measured between the base plate and the electrode clamping device(s) bringing the melting electrical current to the consumable electrode(s).

2.10 Furnace Rated Current, I_n (*rms* Value, *A*) at Nominal Frequency, f_n — Maximum current for continuous operation for which the furnace is designed.

2.11 Rated Values of a Furnace — The rated values of a furnace are those for which the furnace is designed. They are rated furnace current, I_n, rated furnace power, P_n, and rated furnace frequency(ies), f_n.

2.12 Rated Frequency, f_n (Hz) — If the furnace is built for a frequency range, f_n is the value corresponding to the rated furnace current.

2.13 Continuous Operation of a Furnace — Operation during which the solid ingot is produced and solidified, and the consumable electrode is progressively consumed during the whole process.

2.14 Steady-State of an Electro-Slag Remelting Furnace — State of a furnace in which, in continuous operation, electrical and thermal parameters have reached substantially constant values.

3. GENERAL TEST CONDITIONS

3.1 The tests shall be performed in accordance with IS : 9021-1978*.

3.2 The furnace shall be prepared for tests and put into operation at the purchaser's site in accordance with the service instructions and the requirements for safe working.

3.3 The mains supplying the furnace installation during tests shall ensure a symmetry of voltages between separate phases.

*General test conditions for industrial electro-heating equipment.

3.4 The mains supply voltage level at the transformer primary should be within ± 5 percent of the reference voltage levels outside these limits may be admitted in tests, by agreement between the manufacturer and the user. In any case, the test results shall be converted to the reference rated voltage values.

4. TESTS

4.1 The following tests are recommended to be performed in the specified order:

a) Measurement of open circuit secondary voltage of ac installations (or of the open circuit dc voltage in dc installations);
b) Measurement of electrical parameters of secondary circuit of ac electroheating installations (or parameters of the circuit of dc installations);
c) Measurement of active power, apparent power and power factor of the electroheating installations;
d) Measurement of temperature of constituents which are submitted to magnetic field and radiation heating;
e) Measurement of temperature rise of the coolant; and
f) Measurement of energy consumption.

4.2 Measurement of Open Circuit Secondary Voltage

4.2.1 This test is carried out across the melting power supply terminals (*see* point *B* in Fig. 1).

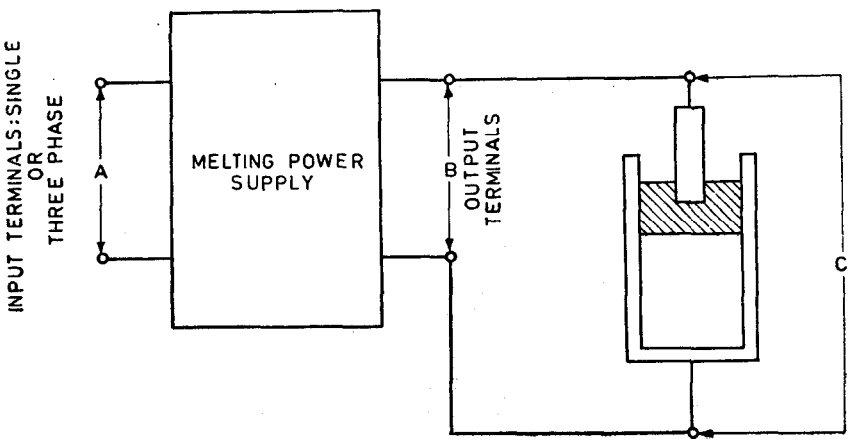

FIG. 1 ELECTRO-SLAG REMELTING FURNACE CIRCUIT

4.2.2 If the installation is provided with a regulation system, the minimum and the maximum open circuit secondary voltages shall be measured.

4.3 Measurement of Electrical Parameters of Secondary Circuit of the Electroheating Installation

4.3.1 This test comprises the following quantities in the secondary circuit (*see* Fig. 1):

a) Active power at the input of the melting power supply (point *A*),

b) Voltage at the output of the melting power supply (point *B*),

c) Voltage of the furnace (point *C*), and

d) Current carried by the secondary circuit.

4.3.2 This test shall be carried out with the furnace equipped with the electrode(s) of the largest weight and length allowed by the designer. The electrical and magnetic properties of the electrode material have to be defined beforehand. The electrodes are brought into electrical contact with the base plate. The power supply is set at its minimum voltage. The voltage is progressively increased until the maximum current allowed by the designer is achieved.

The short-circuit test may give rise to some difficulties and bring about damage of the base plate. In these conditions and in agreement between the manufacturer and the user, it may be substituted by tests allowing to verify that in normal operating conditions of the furnace, the maximum values of the secondary current and of the active power measured on the primary remain in the range admitted by the manufacturer. The latter tests shall be made upon all settings of the supply agreed upon by the manufacturer and the user.

4.3.3 From the above measurements, the following are calculated:

a) Impedance of the secondary circuit,

b) Resistance of the secondary circuit,

c) Reactance of the secondary circuit, and

d) Power factor of the secondary circuit.

4.4 Measurement of Active Power, Reactive Power and Power Factor of an Electroheating Installation — The test comprises measurement at point *A* (*see* Fig. 1) of quantities defined in **2.3** and **2.4**.

The measurement of the active power is made by means of a wattmeter (at least of class 1·5). The measurement of the reactive power is made by a varmeter (at least of class 1·5).

The measurements shall be carried out during continuous operation (*see* **2.13**) of the furnace after steady state (*see* **2.14**) has been achieved.

The power factor is calculated from the active or reactive power values measured as mentioned above or, when the measurement of the reactive power has not been made, from the active power value and the value of the apparent power calculated from the measured voltage and current values.

NOTE 1 — Attention should be paid to the fact that harmonics might affect the results of measurements.

NOTE 2 — The specific energy consumption of an electro-slag remelting furnace depends to a high degree on the slag quality, the fusion rate, etc. If it is to be measured, the test condition and procedure shall be agreed upon between the manufacturer and the user.

4.5 Measurement of Temperature of Components Subjected to Magnetic Field and Radiation Heating — This measurement will be carried out during continuous operation of the furnace after a steady-state has been achieved while the furnace is working at its rated current (I_n).

4.6 Measurement of Temperature Rise of the Coolant Circuit — These measurements shall be carried out during continuous operation of the furnace after a steady-state has been achieved.